- Perennial flowing streams—Sample during low-flow periods. Ephemeral and intermittent streams—Sample immediately after water recedes, while bottom material is still wet.
- The geomorphology, geology, and geography of the area, such as its size and shape, tributary and runoff patterns, streambank structure and lithology, land use, and climate.
- The chemical, physical, and biological character of the water column above the sample-collection site (for example, water depth and hydraulics, fluvial-sediment transport characteristics, and especially the presence or absence of oxygen).
- The chemical, physical, and biological character of the bottom material to be sampled.
  - Chemical characteristics include geochemistry/mineralogy, oxidation state, colloidal/noncolloidal fractions, inorganic/organic composition, spatial and temporal heterogeneity, bioassay data, and data from reconnaissance sampling.
  - Physical characteristics include size fraction, texture, structure, thickness, pore-water content, horizontal and vertical spatial heterogeneity, and temporal heterogeneity.
  - Biological characteristics include population densities, and community structure and diversity of aquatic organisms.
- The use of either statistical or deterministic methods to select the location and number of sampling sites.

8.2.2 NUMBER OF SAMPLING SITES

The number of sampling sites or subareas at a site is determined when the scientific approach to the study is designed.

Statistical or deterministic methods can be used to select the distribution and number of sampling sites. Deterministic methods for selecting sampling sites for bottom material are based on professional judgment alone. Shelton and Capel (1994) discuss use of deterministic models to determine the presence or absence of chemical constituents, carry out surveillance monitoring, identify the occurrence and extent of target constituents, and for environmental reconnaissance. Statistical approaches are used for the more rigorous analyses frequently required for study objectives that address environmental assessments of chemical mass-transport loading and remediation, and temporal and spatial change and magnitude of chemical constituents.

Table 8–1. Applications and limitations of selected statistical methods for selection of sites for collection of bottom-material samples

Stochastic random method
- Commonly used in reconnaissance surveys where little is known about local conditions.
- Most unbiased method of site selection.
- Efficient in areas with homogeneous bottom material.
- Potentially ineffective in areas with heterogeneous bottom material.

Stratified random method
- Often permits elucidation of subtle but real differences.
- Requires knowledge of local conditions.

Systematic regular method
- Randomness achieved through selection of initial sampling site using a number chosen from a random numbers table or from electronically generated random numbers.
- Produces biased results.

Fixed-transect method
- Sites not chosen randomly, therefore any inferences are site specific, and areal conclusions may not be valid.

Statistical methods applied to the selection of sites for bottom-material sampling include stochastic random, stratified random, systematic regular, and fixed transect methods (table 8–1) (Horowitz, 1991; Mudroch and Azcue, 1995).

To determine the number of subareas on the basis of homogeneity of bottom material and the accuracy required by study objectives, see TECHNICAL NOTE, below. Without knowledge of sample variation, the degree to which the data accurately represent the bottom material cannot be known.

TECHNICAL NOTE: Detailed information on estimating sample size using statistical methods can be found in Natrella (1966), Crepin and Johnson (1993), Mudroch and Azcue (1995), and other statistics texts. To determine the number of subareas using equations (1) and (2), obtain a "***t***" table from any statistics textbook. Knowledge of statistics also is required for calculating the standard deviation and understanding how to determine the degrees of freedom:

$$n' = (t_{1-a/2}\ s)^2\ /\ d^2 \qquad (1)$$

$$n_1 = (t'_{1-a/2}\ s)^2\ /\ d^2 \qquad (2)$$

where:

t = a number chosen from a "***t***" table for a desired confidence interval using an estimated value for degrees of freedom (estimate of subareas needed is based on experience),

$_{1-a/2}$ = two-sided confidence interval where a is chosen confidence interval,

s = standard deviation,

d = standard error or variability, in mean concentration, assuming sample mean is normally distributed,

n' = first estimate of number of subareas to sample,

n_1 = final estimate of minimum number of subareas needed to meet required sampling objectives.

Step 1. Compute n' from equation (1) as follows:

a. Choose d (the allowable margin of error) and a (the risk that the estimate of mean will not be off by ± d or more).

b. Choose the number of degrees of freedom appropriate to study needs. Degrees of freedom (*df*) for t are chosen arbitrarily using experience gained from other areas where bottom material has been sampled for the same target constituents.

c. Calculate s from actual data from study area, or estimate s using the formula $s = (R/4)$ at the 95-percent confidence interval where R = expected range of concentrations.

d. Determine t from a t table by calculating $t_{1-a/2}$ using chosen a. For example, if a = 95%, then $t_{1-a/2} = t_{0.975}$.

e. Compute n' where $n' = (t_{1-a/2}\ s)^2 / d^2$.

Step 2. Compute n_1 from equation (2) as follows:

a. Use same values of a, d, and s as in step 1.

b. Determine t from calculating $t'_{1-a/2}$ and using n'**-1** degrees of freedom.

The computed n_1 value should be less than computed n' value. Adjust the various estimated variables—variance (s^2), standard error (d), or confidence interval—accordingly, if greater accuracy is required, or lesser accuracy is acceptable, in meeting study objectives. Remember, this is an estimate.